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POSSIBLE METHODS FOR MEASURING THE EFFECTIVE RANGE OF THE SEX-LURE TRAP FOR PINK BOLLWORM

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INTRODUCTION

The three most common kinds of surveys in pest-control work are for pest detection, for infestation delimiting, and for estimating pest populations. Surveys as we know them today have evolved over the past 100 years or so. Some surveys are conducted today as they were many years ago; others, possibly because of necessity, have become more sophisticated and provide information with high efficiency at low cost.

Surveys in the past often attempted to inspect 100 percent of the units in a population. Before 1969, the survey for citrus blackfly attempted to inspect all citrus trees in a region. We now know that, except under unusual circumstances, the 100-percent survey produces more information than is normally needed or presents such a large task that it becomes physically impossible to accomplish. For either reason, the 100-percent survey is wasteful of scarce scientific resources.

The alternative to 100-percent inspection has always been a sampling system. Many techniques have been invented for defining or obtaining a sample from a pest population. Some of them have been very useful. For example, placing a grid network over an area and choosing certain squares by a systematic procedure has been a useful technique. Some other techniques have given biased results and inadvertently have created much controversy. The road-oriented survey is an example of a system which frequently gives biased results. This system chooses a road through the territory and takes a sample or makes an inspection every so many miles. In the past, surveys for Japanese beetle in rural areas placed a trap along the side of a road every few miles.

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Biometrics, a branch of applied mathematics, has investigated sampling difficulties encountered in the field surveys and developed a sizable body of subject matter and principles to assist in constructing sampling plans which yield unbiased results.

The term "biometrical survey" as used here is a survey which uses a sampling plan. Here, however, the sampling plan is designed according to biometrical concepts. This step tends to insure that the sample will have the capacity to represent the population being sampled. That is, the biometric survey tends to produce representative samples. Further, standard computational techniques may be used to obtain unbiased estimates of means, confidence limits, and probabilities. These biometric principles can be used in planning any of the three kinds of surveys described.

During the last 3 years, the Plant Protection Division has converted the sampling plans of many of its surveys from systems developed over the years to sampling plans based on biometric principles. As a result of this transition, a number of new and effective field techniques and, similarly, new concepts of interpreting field data have developed. The most important of these developments has involved traps, as they are used for surveys, and the interpretations that can be attached to trap catches. The purpose of this study is to describe some of these developments and to indicate further steps that may be made in future surveys.

PINK BOLLWORM SURVEYS

From 1968 to 1970 the California Department of Agriculture and ARS's Plant Protection Division jointly conducted studies of the population dynamics of the pink bollworm. The major effort of this work was concentrated in the 4,000 acres of cotton in Coachella Valley, Calif. This area is east of Riverside, in the general vicinity of Palm Springs. One study, namely the "trap range" test, was conducted in the Imperial Valley.

At Coachella, in 1969, surveys were made for rosette blooms in June and early July. Surveys for infested bolls were made at 2-week intervals from July to November. In December a surface trash survey was made, and in January 1970 a soil survey. In addition to these surveys, 1,000 sex-lure traps of the modified Frick design were distributed uniformly in the cottonfields. Hexalure was used as the bait.[2]

Each of the surveys was designed to conform to a biometric sampling plan. The survey data are representative of the population in the entire 4,000 acres of cottonfields at Coachella. To date, all the data collected have not been completely analyzed. When the analysis is completed, the data will be used to

2/ Keller, J. C., Sheets, L. W., Green, N., and Jacobson, M. Cis-7-Hexadecec-1-ol-Acetate (Hexalure), a Synthetic Sex Attractant for Pink Bollworm Males. Jour. Econ. Ent. 62(6): 1520-1521. 1969.

postulate a model of the annual population cycle in Coachella Valley, and, by suitable statistical techniques, make specific estimates of the numbers of these pests at different times of the year.

In 1968 during the initial planning phases of the operations at Coachella, some of the researchers suggested that at least one sex-lure trap be placed in each of the 95 fields. The usefulness of the trap and especially its "effective range" became the subject of much discussion. Each of the field research investigators had his own opinion as to the effective range of the trap. These opinions varied from a range of 20 feet to a range of 200 feet. Each was a guess based on previous experience. All agreed, however, that an experimental determination of the effective range would be very useful.

A possible test principle was proposed that if traps were concentrated (placed close together), mean catches of moths for a given time might be suppressed. In fact, if several arrays of traps each with a different density could be tested, a relationship might be found between mean catch per trap and the distance between traps. From such a relationship, the effective range could be determined as the distance between traps where they no longer affect each other.

Accordingly, a field test was planned to be conducted in a large cottonfield in the Imperial Valley. Six arrays, each containing four traps at the corners of a square, were defined. The sizes of the six arrays as measured by one side were 1 foot, 3 feet, 9 feet, 27 feet, 81 feet, and 243 feet.

A single block of the test included each of the six arrays. These arrays were located in a random order in a test field 1 mile long and 1/4 mile wide. Arrays were separated by a distance greater than 243 feet. The traps remained for 2 days in the field and then were removed. The test was repeated six times at intervals of about 1 week with a new random order each time. Each repetition was considered as a block. Table 1 summarizes catch means by blocks and arrays.

Table 1.--Mean catches of moths per trap for 6 arrays and 6 blocks

Block	Distance between traps					
	1 foot	3 feet	9 feet	27 feet	81 feet	243 feet
1	52.5	51.5	48.8	71.5	83.0	71.5
2	43.8	67.8	68.0	73.8	79.5	85.5
3	22.8	27.3	37.5	15.3	39.0	45.5
4	9.5	17.5	21.5	41.0	44.0	50.8
5	52.8	53.8	67.8	65.3	88.8	76.5
6	77.8	80.8	101.8	69.3	85.5	92.3
Mean	43.2	49.8	57.5	56.0	70.0	70.3

A statistical analysis of the data showed high significance for the regression between distance and mean catch of moths per trap. Where traps were closer together, mean catches per trap were lower. The mechanism operating here is not entirely understood. One belief postulates that where traps are in dense arrays the concentration of lure in the atmosphere becomes so high and universal that "confusion" develops. That is, because the lure appears almost everywhere the male moths become disoriented and cannot find the traps or the females. Another belief is that when traps are operating near each other they drain the population and the catches of all the nearby traps are suppressed. It is of no importance here which principle is operating; either will provide a basis for evaluating the effective range of a trap.

Although this test terminated with a 243-foot square, the data indicate that the effective range was considerably beyond this distance. Strictly as an extrapolation, therefore, it is judged that the effective range in this case is one distance increment beyond the 243-foot square; namely, the 729-foot square (12.2 acres). Thus, a crude estimate of the effective range of this trap using hexalure as the attractant has been developed in at least one situation.

In August 1969, the field survey at Coachella had to be reduced without impairing the data already obtained. The number of traps used was cut from 1,000 to 500 and distributed on 46 fields instead of the original 95. Also, emphasis shifted from the precisely estimated mean infestation in the Valley as a whole to precise estimates of the infestations within the individual 46 fields.

The boll survey was then redesigned to apply equal sampling to each of the 46 fields without regard to the acreage. The actual sample consisted of 500 bolls as removed from each field. A survey of all 46 fields was completed every 2 weeks. By these changes, some information concerning the mean infestation of the Valley was sacrificed but more than double the information regarding the mean density of infestations in each of the 46 fields was obtained.

The 500 traps were deployed at five densities--1, 2, 4, 8, and 16 acres per trap--in the fields. The mean moth catches per trap for September 1969 were as follows:

Density per trap	Total traps	Moth catch per trap	Acres trapped
1 acre	203	68.5	203
2 acres	99	97.3	196
4 acres	110	113.6	440
8 acres	41	124.7	330
16 acres	30	155.4	469

Trap catches in 1968 through 1970 indicate that 150 to 200 moths per trap is about the maximum that will be captured in a 2-week period using hexalure as the bait. The mean catches for various densities show a very clear trend.

A test of significance has shown this trend to be highly significant. Slight discrepancies in columns 1, 2, and 4 resulted from difficulties in setting arrays at the low densities.

The data from Coachella indicate that the effective range of the sex-lure trap for pink bollworm moths is somewhat greater than 16 acres. Extrapolating these data give a range of about 20 acres. The tests in the Imperial Valley and in Coachella give two independent estimates of the effective range which are in good agreement. In California, apparently about one trap per 20 acres gives a high degree of coverage if hexalure is used as the bait. When more potent attractants become available, the range will probably increase proportionately.

Traps per acre and catches of moths per trap for the 46 fields were recorded in Coachella for September 1969. In addition, live larvae per acre in each of the 46 fields were recorded for October. This was an ideal situation to determine if trap catches represented or could predict field populations.

A multiple regression analysis was made. Traps per acre and catch per trap for each of the 46 fields, in September, were defined as the independent variables. The number of live larvae of the pink bollworm in the bolls for October was defined as the dependent variable. These data were processed using our own program on an IBM-360 computer. The regression showed high significance; both independent variables, traps per acre and catch per trap, showed significant effects. Thus, in at least one situation the trap data did, in fact, predict a population of live larvae.

The data were extremely variable, and while significant, the regression did not give precise estimates. Also, a trap was used, which was originally developed for detecting moths in situations where they were very scarce. Now that the principle that traps can predict populations has been established, in at least one situation, a better trap can be engineered and possibly a better lure can be synthesized. Ultimately, the trap principle can be routinely used as a device for estimating population densities.

We hope that these principles will be tried for evaluating the effective ranges of the many other traps now in use. Since these first efforts, several new and more efficient experimental designs have become available. It seems logical that once designs and lures of traps become better understood, a class of traps intended for pest suppression or eradication will be developed very quickly thereafter.

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